HYGIENIC INSTITUTES.

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[From the Proceedings of the State Board of Health.]

Dr. C. W. Chamberlain,

Secretary of the Connecticut State Board of Health,
Hartford, Conn.

My Dear Sir:

It is with great pleasure that I comply with the request contained in your letter of October the 18th, to furnish a paper for your Annual Report, advocating the establishment of hygienic laboratories in this country. I do this with the greater readiness because I fully share your conviction that an earnest and persistent effort should be made to direct the attention of the general public to the importance of the prosecution of scientific hygienic investigations.

In the following article I have endeavored to sketch in a very brief manner the development of hygiene as a science, and to discuss a few of the researches which seem to me to illustrate the principal objects of its pursuit, and to show in an especial manner the necessity of its further prosecution. Not having access at present to scientific public libraries, I have not been able, in preparing this article, to re-examine several of the papers to which I have referred, which are scattered throughout various medical and other scientific journals, etc., but have been obliged to rely upon the recollection of earlier reading, or upon information received at second-hand: a circumstance which I would plead in extenuation of any minor errors, which may possibly have been made.

In advocating the establishment of Institutes of Hygiene, I have gladly availed myself of the opportunity of urging, incidentally, the claims of our Medical Schools for a more generous public support. If this article should be of any avail whatever in arousing the attention of the public to the importance of the development of the science of hygiene, or in furthering the interests of our medical institutions, I should be more than amply repaid for the labor of its preparation.

I remain,

Yours very respectfully,

GEO. A. SMYTH, ~~Ph.D~~.

Burlington, Vt., Dec. 24, 1883.

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THE UTILITY OF THEIR WORK OF INVESTIGATION, AND THE NEED OF IT IN THIS COUNTRY.

Hygiene, as an experimental science, is of very recent origin. Though many of the present general principles of hygiene have come down to us from remote antiquity; though we find in many of the earlier medical and historical writings of Greek and Latin authors frequent observations on the effects of topographical conditions and of the character of the soil, water, and air upon the health of a people, and more particularly on the influence of these factors in the origination and propagation of pestilential diseases; though in the middle ages the study of hygienic problems was renewed, and has ever since engaged the attention of many earnest students, especially in the ranks of the medical profession, nevertheless the work of *hygienic experimental investigation* is essentially of modern origin, and is the product of the present century. Nor was an earlier development of scientific hygienic research possible. Not until pure chemistry and physics had enlarged our knowledge of the materials and forces of nature, and furnished the means of exact experimental investigation, could hygiene, which derives its methods of research so largely from these branches of pure science, become the subject of experiment and be established on a scientific basis. The development of physiology and pathology also necessarily preceded it, for from them it derives, too, in part its means of investigation. It is not surprising, therefore, to find not only that hygienic research is the work of the present century, but also that its development has been mainly within the last few decades. Isolated investigations of problems lying within the domain of hygiene may, indeed, have been made earlier, but the systematic pursuit of hygienic researches, and the establishment of large, well-endowed and fully equipped institutes or laboratories for the experimental investigation of the influences of our surroundings upon health, are of very recent origin. Mod-

ern hygienic research received its greatest impulse, if it may not indeed be said to date, from the controversies which arose over the causes of the epidemic prevalence of certain infectious diseases, particularly the cholera, and the means of their propagation. It is, furthermore, the experimental study of the etiology of infectious diseases which has given to hygiene its leading direction, and has secured for it recognition, and the means of support.

It is our desire in this article to call attention to the present condition of the science of hygiene, to its aims and its claims for support, for the purpose of urging the importance of the prosecution in our own country of these studies which are now being so earnestly pursued in other lands.

During the prevalence of the cholera epidemic in 1848 in England, the theory was advanced by Snow, Budd, and others, that the infective matters of that disease were taken up by the water of the soil, and that the drinking water was, consequently, the principal means of its communication; and again, in 1856, similar attempts were made by Budd to trace the source of typhoid fever infection to the drinking water. Enlisting general attention, these views found at once both zealous advocates and equally earnest opponents, and a bitter controversy arose over the origin and the means of propagation of these and other infectious diseases, which has raged uninterruptedly ever since, and is still far from a full and final settlement in all of its particulars, though it has been conclusively demonstrated that water is but the bearer, and perhaps not the most frequent at that, of the specific contagion, which has its origin elsewhere. Among the many who entered the lists to combat these views, is Pettenkofer, who has been the most determined and, as the history of the controversy has proved, the most successful opponent of this, so-called, drinking-water theory of infection in its most radical form. Not content with the effort to prove argumentatively that this theory lacked substantial foundation, that in many, if not all the cases of supposed infection through drinking water other factors were involved, in consequence of which the infection could not be traced directly to the water, Pettenkofer endeavored to ascertain by a careful study of all the conditions, and by experiment, what those factors were which combined to spread the infection; and his researches, continued over a period of thirty years or more, have led him to the unalterable conviction that the causes of the epidemic prevalence of certain infectious

diseases, as cholera, abdominal typhus, etc., are to be found *in the soil*, and that it is only through the thorough, systematic investigation of all the physical, chemical, and biological conditions of the soil that their etiology can be finally brought to light. These researches have laid the foundation of hygienic investigation, and have won for Pettenkofer deservedly the title of "the creator of experimental hygiene."

In his early investigations on the etiology of the cholera, Pettenkofer was led to direct his attention prominently to the experimental study of two, as it has proved, very potent factors in the development of certain forms of epidemic disease, to the study, namely, of the *humidity and the atmosphere of the soil*. Suspecting that the varying conditions of the soil as regards the amount of moisture which it contained influenced materially the local and temporal distribution of cholera and other epidemic diseases, he began in Munich the investigation of the movements of the *subsoil or ground-water*, determining periodically its fluctuations, and comparing them with the mortality statistics of various diseases. A comparison by Buhl, in 1865, of the data thus obtained during a long time with the mortality statistics of typhoid fever in Munich, showed, in a most surprising and unmistakable manner, that a very intimate relation existed between the movements of the ground-water and the fluctuations of this disease; the sinking of the ground-water being followed by an increase, the rising by a corresponding diminution in the death-rate from it. The statistical comparison extended over too long a period of time, and the correspondence of the data was too invariable to admit of an explanation on the ground of mere coincidence, or to leave any room for doubt that, in that city at least, an actual causal relation existed between the fluctuations of the ground-water and the prevalence of abdominal typhus. Believing again that the decomposition of the organic matter of the soil might have an important bearing on the etiology of these epidemic diseases, and that the determination of the gaseous products of the decompositions would furnish the readiest clue to the relations, if any existed, between the organic impurities of the soil with their changes and the epidemic prevalence of disease, Pettenkofer entered upon a protracted investigation of the gases within the soil, directing his attention especially to the determination of the carbonic acid. The first results of these investigations, laid before the Bavarian Academy at Munich in 1870, and

published in 1871, showed that our atmosphere does not terminate at the surface of the earth, but, extending below the ground, forms there what is called the soil or ground-air, and that this ground-air takes part in the decomposition of the organic matters of the soil, and consequently becomes richer in carbonic acid and poorer in oxygen than the outer atmosphere. The researches also suggested the question, whether the ground-air was not the main source of the carbonic acid of our atmosphere, and determined its fluctuations. The hygienic importance of the ground-air became at once apparent, and its significance as a health-factor became still more evident when it was found that the carbonic acid did not escape from the soil by simple diffusion, but that between the outer and the ground-atmosphere there was a very free inter-circulation, which was governed by the fluctuations of temperature and of barometric pressure of the air, by the velocity and direction of the winds and by the rain-fall, etc.

These investigations excited immediately the liveliest interest in medical and other scientific circles in Europe. They demonstrated the great value of the line of research adopted by Pettenkofer. They aroused attention in the most forcible manner to the fact that the external surroundings exercised a vast, though unknown, influence upon the health of an individual and the community. They established the conviction that chemical processes and other unseen activities were at work in the upper soil-strata of the earth, which were a mighty factor in the production of disease, affecting not only the water we drink, but also the air we breathe; and they awakened at the same time the hope that through comprehensive experimental investigation, in many different localities, of all the soil conditions, light might be thrown upon the origin of epidemic disease. They stimulated investigation to an unwonted degree, and created an interest in the study of hygienic problems, the fruits of which we are just beginning to realize.

About the time of the publication of these researches by Pettenkofer, Delbrück, in some communications respecting the cholera epidemic of 1867 in Halle, discussed the relations of the temperature of the superficial soil-strata to the development of cholera, and expressed the opinion that the time most favorable for the spread of an epidemic was when the soil had its highest temperature combined with a certain amount of moisture. The study of these questions was quickly taken up by others, and, following the

initiative set by Pettenkofer, hygienic investigators in several different European countries engaged in researches upon the chemical and physical conditions of the soil and their relations to disease. Observations of the soil-temperatures at various depths; determinations of the vertical fluctuations and the flow of the ground-water, and of the humidity of the upper soil-strata; analyses of the soils and drinking waters, especially the determination of the organic matters contained in them; estimations of the nature of the organic soil-pollution, whether of vegetable or animal origin, and of the character of its decomposition (oxidation or putrefaction); determinations of the carbonic acid of the ground-air and its fluctuations, and of the movements of the ground-air; these and other experiments were made here and there, either as isolated investigations or in a more or less connected series. The study of the biological activities of the soil have also engaged earnest attention since Fodor, Schlösing, and Müntz and others advanced respectively the views that the decomposition of the organic matter, with the consequent production of carbonic acid, and that nitrification was not due to chemical agencies, but to the life-processes of microscopic vegetable organisms.

It would far exceed the proper limits of the present article to discuss in detail the researches on these various subjects which, during the preceding decade, have been carried on in several hygienic institutes, or even to mention the part borne by the individual investigators in the gradual development of hygienic laws; and we must confine ourselves to a brief discussion of the results of a very few investigations in their relations to the etiology of certain diseases of an epidemic or endemic nature, and to a general statement of the condition of hygienic science at the present day and the object of its researches.

Next to Pettenkofer, who, in addition to numerous other investigations of a hygienic nature, has steadily pursued the study of the etiology of infectious diseases, and has revolutionized the theories in regard to the origin and mode of propagation of cholera, Fodor, perhaps, has contributed most largely to our knowledge of the relations of the soil, etc., to epidemics and to health, and to the determination of suitable means and methods for hygienic investigation. In a systematic series of investigations on the relations of the air, soil, and water to epidemic diseases, carried on for a series of years in Budapesth, under authority of the Hungarian

Academy of Sciences, he has shown in a very clear and suggestive manner the dependence in that locality of certain forms of epidemics upon the soil conditions and activities, and has demonstrated afresh the great epidemiological value of the kinds of research enumerated above. From the comparisons, namely, of the data obtained through his determinations of the fluctuations and flow of the ground-water, the temperatures of the soil at various depths, the local contamination of the soil with organic filth. and the mode of decomposition of these polluting matters, with the morbidity and mortality statistics of the various infectious and contagious diseases in Budapesth, he has shown that several diseases of the so-called miasmatic and miasmatic-contagious types, as *malaria, enteritis, typhus,** *and cholera*, are, in that locality at least, largely under the controlling influence of the soil, are dependent both in their local and temporal distribution on its varying conditions, and are governed more especially by the amount, distribution, and manner of decomposition of its contaminating organic matters. They are thus all in a sense *filth diseases.*

The influences of the soil upon these various maladies are not, however, identical. The manifestations of a causal connection between certain processes in the soil and the development of a disease varied with the character of the latter. Typhus, for example, was found to be unaffected by the temperature of the upper soil-strata, or by the production of carbonic acid, which, as Fodor shows, can be regarded under certain restrictions as the measure of the putrefactive decomposition of the superficial soil-strata, but was governed very closely in the frequency and intensity of its attacks by the fluctuations of the ground-water. Typhus, therefore, Fodor concludes, is influenced by the changes which take place in the lower soil-strata, in which the ground-water fluctuates.

On the other hand, between the prevalence of malaria and the fluctuations of the ground-water, Fodor could trace no connection, nor could any be found between its prevalence and the humidity of the lower soil strata or the putrefactive processes of the soil. It was, however, found to be dependent upon the temperature of the air and the humidity of the upper soil-strata. A rise in temperature for a few days was invariably followed by an increase in

*By this term Fodor designates the abdominal form of the disease or the typhoid fever of English writers.

the number of malarial attacks, the maxima occurring during the hottest periods; while an increase of soil moisture from the fall of rain, etc., was generally followed by a diminution in its prevalence. Malaria increased, therefore, with the temperature and the dryness of the upper soil-strata, and Fodor concludes with reason that its miasm is the product of the superficial strata of the soil, and affords in this respect a striking contrast to typhus. His further conclusion, that the infectious material of malaria is a micro-organism, which is developed beneath the surface of the soil and is brought, possibly, by the ground-air to the surface and given off into the outer air, is open to serious objection. Granting for the moment that the infectious material is an organism whose breeding-ground is in the soil, it is very improbable that it can pass out of the soil and be taken up into the circulation of the air in the manner indicated, for the soils, even in thin layers, retain these micro-organisms and their germs very tenaciously under air aspirations.

But more striking still are the results of the comparison which Fodor instituted between his soil experiments and the mortality statistics of *enteritis*,* that disease which in its summer ravages yearly sweeps away so many thousands of lives, especially of children. The fluctuations of this disease in Budapesth went hand in hand, during the four years of his observations, with the process of decomposition of the organic matter in the soil, and left no room for doubt that its epidemic outbreak was controlled by the putrefactive decompositions taking place in the upper soil-strata. This view is in entire harmony with the character of the disease and the theory of its origin, viz.: that of a putrid infection. The paramount necessity of a thorough experimental study of the soil in all its relations to health can hardly be shown in a stronger light than by the discovery that the summer diarrhœal complaints are probably diseases which have their source in the soil, that they are caused by an unknown something which is given off from the soil in consequence of certain putrefactive decompositions in its upper layers, and which is taken up into the system, from the air by the organs of respiration, and from food and drink by the organs of digestion. Similar comparisons,

*The term enteritis is apparently used here in a generic sense to denote the various diarrhœal affections and not specifically inflammation of the intestines. Intestinal catarrh is the form most frequently designated by him under this term.

showing an influence of the movements of the ground-water and the decomposition processes of the superficial soil-strata upon the epidemic spread of cholera, were made by Fodor, but it would lead us too far were we to pursue this subject further in detail.

Not only upon the temporal fluctuations of all these epidemic diseases, but also upon their local distribution, was an unmistakable influence of the soil made manifest by these researches of Fodor's. From the results of a house-to-house examination it was found that wherever the soil was most heavily laden with organic filth, and the decompositions assumed more largely a putrefactive character, as shown by chemical analysis of the soil and the ground or well waters, there cholera, typhus, malaria, enteritis, etc., prevailed most extensively. Wherever, on the other hand, the soil was freer from polluted matters and the decompositions were more largely through oxidation, there the mortality returns from infectious diseases of "miasmatic or miasmatic-contagious" types were generally far lower. No connections between the contagious diseases, measles, scarlet fever, croup, and diphtheria, and the contaminations of the soil could be traced by Fodor.

In judging the results of researches of the nature described above it must be borne in mind that they have as yet been tried only in a few places and have been continued during comparatively short periods of time. The value of the work already done lies more, it may be said, in the promise of future discoveries than in the present realization of definite results. The results obtained in different places do not agree in every particular; nor, indeed, could such an agreement be expected, as the conditions under which the experiments are tried vary very materially in different localities. Such experiments, with all the additional aids that time and experience may suggest, need to be carried on, therefore, for a long time and in a large number of places of unlike physical and geological character. The work already accomplished seems, however, as Fodor has stated, to point very clearly to one general conclusion, namely, *that it is the filth of the soil and its decompositions which lie at the foundation of certain forms of epidemic disease.* From the decomposing filth of the soil, the water and the air probably receive the morbific matters which they convey to the human system. It is the decomposing organic

matter of the soil to which, according to present indications, we must look in the ultimate analysis as the cause of the origin and development of infectious disease, and to which the other factors alluded to above must be referred. Changes in the temperature or the humidity of the soils or the air, the height, the vertical fluctuations, the flow, or the stagnation of ground-water, could not of themselves, it may fairly be inferred, produce the conditions favorable to the origination and spread of an epidemic. They are secondary factors which exert their influence whenever and wherever the essential prerequisite exists, viz.: the presence in the soil of decomposable organic matters in sufficient quantities.

In proportion as the evidence in favor of a vast epidemiological significance of the soil increases under the advance of hygienic investigation the more immediate and pressing becomes the necessity of ascertaining the character of this influence and the way in which it is exerted. What is the nature of the emanations from the soil which at certain times in particular localities tend to produce an epidemic outbreak of some special form of disease, or, if not themselves directly to produce it, at least to aid in its generation? In what way do these emanations, acting both through the water and the air, exert their influence upon the human organism? Though much is being learned, as we have seen, in regard to the conditions which favor their action, we are still left almost wholly to conjecture as to what they are and how they act. So far as our present knowledge extends, however, it seems probable in the highest degree that the influence of the soil, air, and water upon the so-called miasmatic-contagious diseases, typhus, cholera, yellow fever, etc., is not direct, *i. e.*, that these media do not of themselves produce the diseases or the specific contagious elements. On the other hand, the influence of the soil in producing the purely miasmatic diseases, under which head, besides malaria, the various enteric complaints must probably be classified, is apparently more direct, though this has by no means been conclusively proven. But if the influence of these emanations from the soil be indirect, do they act, as is commonly supposed, upon the human system in such a way as to lower its tone, to render it more susceptible to infection from a disease and less able to withstand its attack; in other words, do they produce the *individual disposition?* or do they act, as Pettenkofer is more inclined to believe, upon some matter given off from diseased persons which thereby

acquires its specific contagious powers? Again, considering the nature of the emanations from filthy soils, which are thus directly or indirectly instrumental in generating various epidemic diseases, do they consist, as Naegeli, and following him Fodor also, endeavors to prove, of a certain class of microscopic vegetable organisms, "*miasmata-fungi*," which, propagating and developing in the human body, so alter the chemical condition of some one of its liquids as to prepare it for the attacks of the specifically pathogenic organisms, the "*contagia-fungi*"? or are they rather, as Wernich and others suppose, unorganized matters, *putrefactive gases*, which, acting upon the system, lower its vitality and debilitate it to such a degree that it is no longer capable of successfully resisting the invasions of micro-parasites which are present in the body? These are questions to which at present no definite answers can be given. The whole matter is shrouded in mystery; to unravel which a vast amount of patient, unremitting, and systematic investigation will be necessary. We must first study more thoroughly and comprehensively the chemical activities of the soils. We must determine more accurately the chemical nature of the gaseous and other products of decomposition of the organic filth in polluted soils, and ascertain their pathological significance, if such they have. Again, we have to study in all their details the biological activities of the soils. We must ascertain the origin, character, and mode of development of those low forms of vegetable life which are produced or contained in the soil; determining the changes, both morphological and physiological, which they are capable of undergoing, and the influences which the soils exert upon them. Following out the natural history of these organisms in the soil we must then investigate whether any, and, if so, what soil-organisms are capable when taken up into the system of producing disease or of paving the way for the action of other distinctively pathogenic organisms. In short, we must study the whole life history of micro-vegetable organisms both in the soil and the human body. We must trace out, furthermore, the characteristic differences, both chemical and biological, between the pure and the filth-polluted soils.

In discussing the work of hygienic researches we have dwelt in the foregoing pages more particularly upon the results of certain chemical and physical investigations, which have seemingly established the fact that the soil is capable of exerting a wide-

reaching and important influence upon the health of individuals and of communities. But we have reason to suppose that the decomposition of the organic matters of the soil, especially those of a putrefactive nature, upon which this influence depends, may be in a large measure due to the life processes of certain low orders of vegetable organisms, and furthermore, so far as we can at present see, the soils furnish but one factor in the genesis of many if not all the epidemic diseases herein discussed, in that they produce an unknown something which either acts upon the individual, predisposing him to the invasion of the specific contagion of a given disease, or acts upon certain matters given off from diseased individuals to produce the specific contagion itself. Whatever the origin of these specific contagious principles may be; whether they are the product in some obscure way of the soil and the individual jointly, or of the diseased individual solely, or, again, are of utterly unknown origin, there are many reasons for believing that they are organized elements. The vast hygienic importance of the thorough study of the natural history of microorganisms, of their relations to health and of the part which they bear in the etiology of disease, becomes at once apparent and cannot be too strongly emphasized. It remains, therefore, to say a few words in regard to the work which is being done in this field of hygienic research.

Through the investigations of microscopic botany and of physiology the existence has been brought to light, as is well known, of an almost innumerable number of varieties, species it may be, of minute organisms, which are mostly of a vegetable nature and which derive their sustenance from various kinds of animal or vegetable organic matter. Multiplying with immense rapidity wherever the conditions are favorable for their development, in one form or another these organisms or their spores are almost universally present. They are distributed through the soil in the flow of the rain or the ground-waters; are taken up in the dry state by the air, owing to their almost infinitesimal lightness, and swept hither and thither as an invisible dust. Now borne onward in a current of air or water, now settling on all exposed objects, they remain in a quiescent state or renew a developmental activity, according to the nature of their surroundings. Through the activities of these various classes of organisms the decomposition of organic matter is in the main effected. The souring of liquids,

as milk, beer, etc., and all other forms of fermentation; the rotting or decaying of fruits and vegetables, and the putrefying of animal matters, are invariably caused by the growth in them of some form or forms of minute organisms, and are an inseparable accompaniment of the process of growth of these living organisms. To the active development of these vegetable fungi a certain amount of warmth and moisture is essential. Though frequently able to survive exposure to intense heat or cold or the application of powerful chemical agents, their multiplication and development can be retarded or entirely checked for a time by the employment of one or the other of these agencies. The preservation of foods by canning, by salting, pickling, smoking, or other chemical process, by desiccation or refrigeration, is due either to the exclusion from them of all such organisms and their germs, or to the prevention of their growth and self-multiplication.

Not only do many of these low vegetable forms subsist upon dead organic matters, the various products of higher vegetable and animal life, but they are also able under favorable conditions to attack the living organisms themselves, to conflict with the normal activities of their cells, appropriating and decomposing their plastic materials and, as true parasites, developing on or within the plants and animals at the expense of their cells. From the discovery of these facts one of the greatest advances of modern surgery, the introduction of Lister's antiseptic method of operating, and of dressing surgical wounds, has resulted. The performance of surgical operations under a spray of carbolic acid or other antiseptic, the use of sterilized instruments. the application of carbolized cotton and bandages, etc., preclude in a measure the noxious organisms floating in the air from contact with the wounded surfaces, and prevent such organisms as have gained admission from active development and the resulting septic infection of the blood. The beneficial effects of this method in severe operations, especially in crowded hospitals in which the air is often swarming with pathogenic organisms, has been very marked, the comparative freedom from subsequent blood-poisoning permitting a much larger percentage of successful results than was attainable before its introduction.

The discovery of these numerous low organisms, and of their power under certain conditions of developing within the human

system, could not fail to lead to the inquiry whether a deep pathological significance was not to be attributed to them. Might not the presence and the growth of these organisms in the body be intimately associated with the genesis of disease? Might not the immediate cause of all zymotic diseases be the rapid multiplication and development in the system of some low organism whose life processes are antagonistic to those of the individual? The morbific and contagious principle of a disease would thus be an active, living organism, and the disease itself would be at once the result and the sign of the conflict between the normal processes of cell life of the individual and the self-multiplying or growth-power of this foreign organism. Accordingly as the one or the other ultimately prevails in this struggle for existence the disease terminates in recovery or in death.

Recent pathological researches have indeed shown that all highly infectious or contagious diseases, and some others, as pulmonary consumption, the contagious character of which is not so distinctly marked, are accompanied by the presence in the blood or affected organs of certain microscopic plant-growths, and have led to the almost universal acceptance of the theory of the germ origin of zymotic diseases. They have, furthermore, firmly established the conviction in the minds of many that for every infectious disease there is a specific organism which is peculiar to it and which produces it. The existence of a characteristic organism, which will produce a given disease, and which is invariably present in that disease and in that alone, has, however, been as yet but very rarely conclusively proved. Most clearly has such a genetic relation between a given disease and a particular organism been traced in Koch's remarkable researches on the origin of splenic fever, which have fully proved that this malignant malady is caused by a well-defined, peculiar vegetable growth.* In many forms of disease the supposed discovery at one time or another of the presence of a specific organism has been disproved, or at least has not been confirmed by subsequent investigations,† while in

*The *bacillus anthrasis*, which was first discovered by Davaine in the blood of sheep and cattle that had died of anthrax. A microbe, which is the apparent cause of swine-plague, has been isolated and studied by Klein, and another, which produces chicken cholera, has also been detected and cultivated by Toussaint. Koch's remarkable discovery of the *bacillus tuberculosis*, and seeming demonstration that this microbe is the cause of tubercular consumption, should also be mentioned here.

†The existence especially of a specific organism that produces malaria has been repeatedly denied, and also reaffirmed by different investigators, since the alleged discovery of a *bacillus malariae* by Klebs and Tommasi Crudelli.

others their presence has only been suspected. Generally the organisms found in the blood or affected organs are such as are common to many diseases, or are frequently found elsewhere, and possess no peculiar pathogenic character. They are not, then, peculiar to a given disease, nor has it been proved that they can give rise to it, or that they are more than accidentally present during its attack. It has not been shown that they are more than mere accompaniments of the disease which owes its origin to some other cause. It may be that the disease produces conditions which are favorable to their development, while under the normal conditions of the bodily functions they are destroyed or rendered inactive by the chemical activities of the body.

Though the germ theory of disease in its general form is well-nigh universally accepted, this view that there is a specific organism for each and every form of infectious disease is by no means shared by all. As Naegeli has shown, there are many reasons for supposing that the innumerable varieties of micro-organisms do not form natural-history species, which reproduce themselves with unfailing regularity, cause the same decompositions, and, in case of pathogenic action, give rise invariably to the same symptoms. These organisms seem to possess to a remarkable degree the power of adaptation, the capability of changing by regular gradations not only their morphological but more especially their physiological character, according to the nature of the nutritive materials which are afforded them and the physical conditions with which they are surrounded. By repeated cultivations in appropriate media innoxious varieties of organisms may in time become indued with the most virulent properties, while conversely organisms exercising distinctive and intense pathogenic powers may ultimately be brought to reproduce harmless forms. The possibility of this, at least, has been amply demonstrated by Buchner's experiments. The pathogenic organisms may, in accordance with this, be modified forms of other more common varieties and not distinct species. It remains, therefore, for future investigation to determine whether each germ disease is caused by a distinct, unvarying species of organism or by some common variety which is in a particular stage of development and indued with unusually active, peculiar powers.

Not only may a micro-organism, which occasions a given disease in a human being or some lower animal, be rendered entirely

innocuous through successive cultivations in different media, but it may also, by culture in some other animal or in appropriate media, be so "attenuated" or changed in character as to produce the disease, indeed, but in a milder or perhaps essentially modified form, and through the introduction of this less deleterious form of the disease to protect the system for a time against its attacks of a severer character. The efficacy of vaccination is, undoubtedly, due to this. The brilliant researches of Pasteur on chicken-cholera and the anthrax of sheep show that this principle is capable of a much wider application, and inspire the hope that the thorough experimental investigation of pathogenic organisms will lead in time to the determination of means of inoculation whereby human beings and the useful lower animals may be protected from the ravages of all deadly contagious diseases. Already the claim has been raised of similar results in some very recent investigations of yellow fever, but of the results of these and of some other recent investigations on scarlet fever it is, as yet, too early to judge.

Such are the directions of some of the most important researches of modern hygiene. Their object, it will be seen, is the thorough investigation of all the etiological factors of epidemic disease. They comprehend the investigation in many different ways of the principal sub-strata of life, *the soil, air, and water*, with reference to their pathological effects. Gradually this work, originating in a few private researches, is obtaining public recognition and support abroad. Already several of the European governments, Germany especially, awakened to a sense of the grave importance of a more thorough study of all zymotic diseases, and convinced, through the distinguished labors of Pettenkofer and other pioneers, of the utility of hygienic investigations, are beginning to establish large institutes or laboratories for the promotion of the science of hygiene in all its branches, and are enlisting in the cause of hygienic research the services of many men of eminent and varied scientific attainments. Amply provided with all needful apparatus, liberally endowed with means for investigations, and, above all, furnished with a corps of able and skilled investigators, may it not reasonably be hoped that these hygienic laboratories will in the future be of very material service in ferreting out the causes of various diseases and in discovering proper measures for their mitigation and ultimate total extinction, and hence become of lasting benefit to humanity?

What, meanwhile, is being done in our own country to advance this important work of investigation into the causes of the origination and spread of epidemics? So far as any organized, systematic, and sustained efforts are concerned, it must be answered—NOTHING. The few isolated researches which are carried on here and there are the work of private individuals, unsupported by the national or state governments, and unaided, if not unrecognized, by the public. The National Board of Health, it is true, during the few years of its active existence, endeavored to encourage hygienic investigation by supporting in different places special researches on some of the epidemic diseases and on questions of general sanitary importance; and the hope was entertained for a time by some that these labors of the Board would ultimately lead to the establishment of a permanent hygienic institute, with an organized corps of special investigators, in which the subject of epidemic disease and other important problems of experimental hygiene could be investigated in a more comprehensive and systematic manner than is possible by detached researches in separate laboratories. But these hopes were doomed to disappointment, and the Board of Health itself, after a brief period of activity, was practically abolished through the refusal of Congress to make any adequate appropriation for its maintenance. Nor is the necessity of scientific hygienic research recognized and appreciated by the general public. Excepting by the members of the medical profession, if indeed by them very generally, the true character of this work is as yet but little understood. Public interest in matters pertaining to general sanitation has been aroused, indeed, and is yearly becoming more and more widespread, as is evidenced by the establishment of numerous local Sanitary Protective Associations; but the objects of these societies are generally of a somewhat superficial character and their labors are almost exclusively confined to the discussion of practical sanitary regulations. The investigations carried on by them are of trivial importance. The need of developing the science of hygiene is nowhere recognized as it should be.

If sporadic cases of typhoid fever occur in any locality we attribute them at once to the use of impure drinking-water, and if, on a single, hasty chemical examination, a certain amount of organic matter is found in the water, the disease is "*traced*" to its origin in some well or spring, which has clearly become contaminated

from some neighboring cess-pool or other source of pollution. But we remain in ignorance of the other influences which may be at work around us, and unmindful of the fact that the disease could not have originated in the well or the cesspool; that the water, therefore, could have been at the most but a carrier of the infection. The single chemical analysis of the drinking-water, of little value at the best, is often positively pernicious in its effects, inasmuch as it diverts the attention from a thorough study of all the possible factors in the production of the disease, and frequently gives rise to a feeling of false alarm or equally false security. If diphtheria, scarlet fever, etc., appear in a household the house drainage is immediately held in suspicion, and these maladies are "traced" again to defective plumbing and the dreaded sewer-gas. But we attach no importance to the fact that other agencies are at work here over which the ignorant or wicked plumber has no control; we are heedless of the possibility that the vitiated air of a surrounding filth-polluted soil may be entering the dwelling through cellar or basement and circulating through all its rooms, and are unconscious that this soil-air, though entering unseen and betraying itself by no sickening odor, may often be far more baneful in its effects than sewer-gas itself. And so on through the list of infectious and contagious diseases. Again, if an endemic outbreak of disease occurs, attention is immediately directed to the necessity of extra sanitary precautions, such as the removing of all filth from cellars or back-yards, the clearing out and disinfecting of all cesspools, privy-vaults, drains, etc. All this is well enough so far as it goes, but it alone will never prevent the outbreak or further spread of epidemic disease, still less will it throw any light upon its causes and means of propagation. We frequently content ourselves during the prevalence of an infectious disease with simply putting all noisome matters out of sight by covering them over or burying them in the earth. But such is our ignorance of the nature of diseases and of the influences of the soil upon their propagation that we cannot be sure that in loading the soil with filthy, and especially with infected, matters we are not putting them where they will have the best possible opportunities to do harm. Once more, if a disease breaks out in a most violently epidemic form, threatening not only single localities but also entire communities, the governments, state or national, are stimulated to activity, and besides the tremendous exertions to

stamp out the existing epidemic a feeble effort is also made to investigate it. A commission is perhaps appointed to inquire into the cause of the outbreak and—*report*. But in time the epidemic is checked or dies out, and the work of investigation into its etiology is no longer supported and is discontinued until some new sudden emergency calls forth a renewal of these spasmodic exertions.

Haste and a lack of thoroughness are the chief characteristics of all these efforts to grapple with the problems of epidemic disease, and nowhere are these unfortunate American peculiarities more disastrous in their consequences than here. By no such efforts can these immensely difficult problems ever be solved. The etiology of an infectious disease cannot be investigated by researches which are carried on only during the prevalence of an epidemic of that disease. Possibly the time for investigating some of its factors is already past, and a more prolonged study of all of them is necessary. It cannot be worked out through the unsupported, isolated investigations of single individuals, who are obliged to devote the main portion of their time to the practice of their profession or to other pursuits. It cannot, finally, be worked out by the labors of a single class of investigators alone. We are accustomed to leave the study of the causes as well as of the treatment of disease entirely to the medical profession. But the practicing physician alone cannot search out the etiology of a "miasmatic" or "miasmatic-contagious" disease. He has neither the time to conduct the necessary experiments nor the requisite training to investigate some of the essential factors. Nor can the biologist or the chemist alone determine all the separate factors. Only by the patient, long-continued and united labors of workers in all these departments can the operative external influences with their separate and combined effects be thoroughly traced out. And the work must be done, in great part at least, in our own country: we cannot rely wholly upon the labors and discoveries of foreign investigators, but must study in many different places our peculiar local conditions with reference to endemic and epidemic diseases. For many of these diseases statistical observation is the only method of investigation which seems to give promise of successful results. This method requires, it is evident, years of unbroken, persevering study of all the possible influences of our entire external surroundings, as the soil, the air, and water. To

carry on this work of experimental study the necessary facilities must be created. Hygienic laboratories must be established and a permanent force of special investigators employed to conduct the various physical, chemical, biological, and pathological experiments.

It must be acknowledged that the task before us is one of exceeding difficulty. We are fighting an unseen foe. The influences at work to produce epidemic disease are many and complicated; our means of tracing them are frequently inadequate. In spite of all our facilities and the labors of many workers it may be years before the etiology of a single epidemic disease will be thoroughly worked out; it is not impossible that some forms of disease will forever baffle our efforts. But shall the earnest attempt to investigate these diseases not be made, because the way is beset with difficulties and the successful issue of the conflict not assured at the outset? Surely the prevalence of epidemic diseases in our midst is a subject of sufficient importance to demand our most serious attention, if there exists even a remote possibility of our being able to investigate their causes. Enteritis in its different forms produces with each recurring summer a frightful amount of infant mortality. Scarlet fever, diphtheria, membranous croup, etc., sweep away annually thousands of lives, among the young. Typhoid fever claims many victims, appearing here as a sporadic disease, there again as a severe endemic. Malaria ruins hundreds of lives, and in some parts of the country is on the increase and is gradually extending its domain, appearing year by year in places it has never visited before. Small-pox and especially yellow fever break forth at intervals in the form of frightful epidemics, and within a very short time cause a terrible destruction of life and occasion the loss of millions of dollars' worth of property. In the face of these facts shall we as a nation do nothing to support the efforts of those who are endeavoring to investigate the causes of such diseases, and thus to lay the foundations for comprehensive prophylactic measures? The expenditure of vast sums of money and years of laborious toil would certainly be none too great a sacrifice if these efforts should be crowned with even partial success. Do not the methods of investigation of epidemic diseases discussed above and now being tried in other lands seem to hold out a sufficient promise of success to warrant their further extension, and their introduction into this country also? If they do,

then beyond a question they should be immediately and liberally supported.

We have discussed in this article the work of hygienic laboratories solely with reference to the investigation of the etiology of certain infectious diseases But though this is the work of hygienic investigation which is of the most immediate and urgent importance, the researches of scientific hygiene are by no means limited to this one subject. The soil, air, and water exert, undoubtedly, a profound influence upon the general health apart from their important relations to any specific form of infectious disease, and it is a further work of experimental hygiene to search out this influence. A more thorough experimental study of means and methods of disinfection is also imperatively necessary. The most comprehensive and effective methods of disinfecting cannot, it is true, be determined with advantage until the nature of infection itself is more thoroughly understood; but nevertheless, as we are often obliged to adopt practical measures to prevent the further spread of a disease, notwitnstanding our ignorance of the nature of its infective matters, it is of very great importance for us to determine experimentally the relative efficacy of these various measures in destroying the contagia, or in counteracting their influence. There are, moreover, many other special subjects of hygienic investigation. There is, to enumerate a few of these, the study of foods and clothing in their relations to health subjects which require an immense amount of chemical and microscopical investigation. Again, there are the many and complex influences of our dwellings upon our health to be investigated. We have here to determine the effects of building materials of various kinds upon the natural ventilation, the temperature and the humidity of the houses, and the influences which our methods of heating and lighting and our systems of house-drainage exert in contaminating the air of the rooms; and finally we need to investigate experimentally the subject of ventilation, with reference to determining the limits to the natural ventilation and the amount of artificial ventilation which is consequently necessary in private and in public buildings. The influences of various occupations, so far as they can be made the subject of experiment, are also objects of hygienic investigation.

In brief, it is the province of the science of hygiene to investigate the influences of all our surroundings which are more or less

continually active and, hence, not of an accidental nature, and which produce effects upon health of a serious and lasting character. Hence, its work is of a very multifarious character. Its varied investigations require the aid of many special branches of pure science, as *chemistry*, *physics*, *geology*, *microscopic botany* and *zoology*, etc. It is most intimately associated with the departments of *physiology* and *general pathology*, to the latter of which in particular it forms the natural supplement. It is, perhaps, this wide diversity in the objects of its work which has prevented hygiene from obtaining an earlier recognition as an established branch of applied science, and which has led many to suppose that its researches should be left to the various branches of science whose services it employs. But it can safely be affirmed that under such circumstances hygiene could make but very little advance as a science. If the special chemical researches of hygiene, for example, were left to the department of chemistry they would probably never be pursued, as the discoveries of greatest hygienic importance would not be of especial value to chemistry as a pure science, nor would they promote materially its development. That these researches may be pursued, it is therefore necessary to establish the branch of *hygienic chemistry*, just as it was found indispensable to the interests of agriculture to create that of *agricultural chemistry*. And so it is with all the other pure sciences upon which hygiene depends. Nor can general pathology, with which it is most intimately connected and from which it cannot be separated by any sharply-dividing line, absorb the work of hygienic research without an undue extension of its own limits and methods of investigation. In a general sense hygiene ends, it is true, where pathology begins, but we cannot well determine the various external influences which seriously or permanently affect the health without at the same time investigating the mode and the character of the affection, and so hygiene must necessarily include within its legitimate sphere of activity a portion of the researches of general pathology, and cannot be divorced from it. If, then, hygiene is to be established on a firm basis as an independent branch of science, and its interests are to be zealously promoted, it must have its own temples and votaries; special laboratories must be built and equipped with all the needful appliances for the varied class of investigations, and men must be employed whose

life services shall be devoted to the single pursuit of these multifarious special researches.

But how are such INSTITUTES OF HYGIENE to be established, and by what means are they to be maintained? In Germany and other European countries they are supported, as we have seen, by the government, and unquestionably this is a work which should be taken up and maintained by government everywhere. *There should be, at the least, several large and fully equipped hygienic laboratories permanently located in different parts of this country*, and, as this would involve the expenditure of large amounts of money, it should be the care, as it is the duty, of our national government to provide the means for their foundation and continued support. Unfortunately the character of our general government is not such as to inspire the hope that Institutes of Hygiene would be maintained by it in any proper and adequate manner. The work, it is evident, must be carried on uninterruptedly for years, if it is to have any real value. It cannot be productive of results if liberally supported for a year or two and then neglected, as was the work of the National Board of Health. If these laboratories were dependent on annual congressional appropriations, they would be liable at any time to have their means of support cut down or wholly withdrawn, according to the caprice of Congress, without any regard being paid to the character and importance of their work. Unless they could be made independent of congressional interference they would lead a very precarious existence. If founded by the general government they should be established in some such way as were the agricultural colleges, and thus put forever beyond the control of Congress. Unless some such plan could be adopted, it cannot be denied, as our government is constituted, that their prospects of usefulness would be much brighter if they were maintained by the separate States, or permanently established on an independent basis by means of private benefactions. The great expense involved is the only practical difficulty in the way of these methods of establishing them, and this is by no means an insuperable obstacle.

Whatever means are employed to establish them—whether they be founded by the national government, or supported by state aid or by private endowments—they should, some of them at least, be established in connection with our medical institutions. There are several reasons in favor of this. An intimate relation subsists be-

tween a very important part of their work and that of some branches of medical science, and the work as a whole is naturally associated with the department of medicine. The hygienic laboratories require the services of men of medical training for many of their researches, and it is from this professional class, more than from any other, that their staff, which is to be trained to the work of special investigation, should be recruited. But aside from these advantages to the hygienic laboratories, their connection with the medical schools would be the means of promoting instruction in hygiene at these institutions. This is an important consideration. We naturally expect the physicians of the country, by virtue of their training and position, to be the leaders in all efforts to advance the sanitary interests of the single communities in which they reside and of the public at large. As a class they have the best and most frequent opportunities of judging the conditions of our surroundings, as regards their effects upon health. They should, therefore, be qualified to detect the presence of unsanitary arrangements and to instruct the people in regard to necessary local sanitary improvements, as well as to advise the municipal or general governments what public sanitary measures should from time to time be adopted. They need, consequently, to be familiar not only with the general principles of hygiene, but also with the most recent discoveries of hygienic research. At present the medical profession does not occupy the position in these respects which it ought. There is many a physician of acknowledged therapeutical skill and experience, who remains in ignorance of the advances of modern hygienic research and who is unable to advise intelligently in regard to matters of most urgent sanitary importance. For this he has had little or no training and has not found or improved the opportunity of compensating for early deficiencies through later studies. In many of our medical schools hygiene is not taught at all, while in others the instruction is confined to a few lectures, mostly on the subject of personal hygiene.

But in order that hygienic laboratories may be advantageously added to our medical schools and the department of hygiene raised in these schools to a proper standing, it is necessary that the system of medical instruction be materially modified and enlarged, and that a graded course of study be adopted, as in other institutions. Comparatively few of the medical schools are able to have a graded course or a nine-months' term of study during the year,

and only one has as yet adopted a full four-years' course of study. Even here a fourth-year's course of study is not made obligatory, though strongly encouraged.* This much-to-be-desired advancement of medical instruction is not, however, possible unless the institutions are properly endowed; and it seems here a fitting opportunity to digress for a moment from our especial subject, in order to urge the claims of our medical schools upon the public for recognition and support. One would naturally suppose that the medical institutions would be the first to receive the fostering care of a government and the public. And yet in this country the reverse is the case. While our academies, colleges, and other seminaries of learning are frequently the recipients of liberal donations and are encouraged and sustained by the favor of the community, our medical schools, strange as it may seem, appeal in vain for aid or sympathy. No school has been founded on an independent basis; but few, if any, have received more than the most meagre endowments, while all have had to struggle for an existence and to contend against the indifference of the educated classes and the ignorant prejudices of the populace. The medical profession is the one from which the public demands the most—for which it does the least. And this notwithstanding the fact that this profession is the one above all others with whose success the interests of the public are most closely identified! It is the people in general who reap the advantage from every advance in medical science, from every successful effort to raise the standard of the profession. It is for the interests of the community, then, to aid the medical institutions of the country in the efforts both to promote the efficiency of their instruction and to advance the science which is of so great an importance to mankind. Gradually the idea is gaining ground that the work of our higher educational institutions should not be confined to the instruction of the class or the lecture room. We are beginning to realize that these institutions have another and a larger sphere of usefulness; that they

* Two other medical schools (see the very valuable section of the Annual Report of the Illinois State Board of Health for 1883 on "MEDICAL EDUCATION AND THE REGULATION OF THE PRACTICE OF MEDICINE IN THE UNITED STATES AND CANADA") announce, it is true, a *four-years' graded course of instruction*, but these institutions have been but very recently established—in 1881 and 1883—and have only three and four instructors respectively. Canada is apparently much in advance of the United States in regard to the method and the extent of her medical instruction, as *all of the medical institutions*, registered in the above mentioned report, *have a graded course of study of not less than three years, and several of them have a four-years' course.*

should be the centers of the intellectual activity of our national life, and, through the work of original research, should enlarge the bounds of our knowledge in every field of thought. In no institution of learning is this more necessary than in the schools of medicine. The medical department of a university should not confine its labors solely to the work of preparing young men for the practice of their arduous profession, but should endeavor also, through the steady pursuit of investigation, to develop the science of medicine in all its branches. In order, however, that they may be able to accomplish this work, and impart instruction as well, in the most thorough manner possible, they must be able to maintain a large and permanent staff of professors, whose time will not be occupied wholly with the work of the lecture-room or with the outside practice of their profession, but can be devoted in large part to the advancement of their various departments. They must, furthermore, be furnished with the necessary museums, pathological institutes, physiological and chemical laboratories, etc., and equipped with all the forms of apparatus which are needed for the prosecution of researches or for lecture illustration; and, finally, they must be supplied with means to pursue these investigations. Surely a greater work for humanity cannot be done in this country than through the establishment of such an institution on a firm and independent basis, nor can a grander opportunity be found for the bestowal of private benefactions.

Such, in brief, is the position which the medical schools of the country should occupy. With these schools, thus liberally and permanently endowed, there should forever be associated the Institutes of Hygiene, the work of which we have attempted in the present article to outline. Contributing in a not unimportant degree to the education of the general medical practitioner, training a certain class of men for the work of special scientific investigation, and, above all, steadily and systematically pursuing experimental researches on the etiology of disease and on other subjects of vital importance to health, they cannot fail, if properly established, to achieve a work of great and lasting benefit to mankind, the full results of which we as yet but very imperfectly realize. Shall they not, then, be established? Shall we not as a nation enter into this great work immediately and earnestly, heartily supporting it through the means of government or by private benefactions and prosecuting it to the utmost extent of our power?